

## Physics 230

### Homework Set 8

1. Two spaceships  $A$  and  $B$  are moving in opposite directions, each measures the speed of the other to be  $(4/5)c$ . Relative to our frame of reference, spaceship  $A$  moves to the right and spaceship  $B$  moves to the left. Each spaceship contains two clocks with one at the nose and one at the tail, synchronized with one another in each ship's frame. For spaceship  $A$ , label the clocks as  $N_A$  and  $T_A$  corresponding to the nose and tail clock of  $A$ , respectively. Likewise, for spaceship  $B$  label the nose and tail clocks as  $N_B$  and  $T_B$ . The rest length of spaceship  $A$  is 150. m and the rest length of spaceship  $B$  is 450. m. Just as the nose of  $B$  reaches the nose of  $A$ , both ships set their nose clocks to read  $t = 0$ . Analyze this problem from the rest frame of spaceship  $A$ .
  - a) Sketch both spaceships from  $A$ 's point of view at the moment when the noses meet.  
Use a ruler to make sure that your drawn lengths are consistent with your calculated values. State the scale that you are using in constructing for your images.
  - b) At this moment described in a), what are the readings of all four ship clocks?
  - c) How long does it take the tail of  $B$  to reach the nose of  $A$ ?
  - d) When the tail of  $B$  reaches the nose of  $A$ , again sketch both spaceships from  $A$ 's point of view.
  - e) At this moment described in d), what are the readings of all four ship clocks?
2. Reconsider the two spaceships of the previous problem, this time from the rest frame of spaceship  $B$ .
  - a) Sketch both spaceships from  $B$ 's point of view at the moment when the noses meet.  
Use a ruler to make sure that your drawn lengths are consistent with your calculated values. State the scale that you are using in constructing your images.
  - b) At this moment described in a), what are the readings of all four ship clocks?
  - c) How long does it take the nose of  $A$  to reach the tail of  $B$ ?
  - d) When the nose of  $A$  reaches the tail of  $B$ , again sketch both spaceships from  $B$ 's point of view.
  - e) At this moment described in d), what are the readings of all four ship clocks?

3. Reconsider Problems 4 and 5 from Homework Set 7. “A spaceship passes earth traveling at a speed  $V = (5/13)c$  and is heading for a distant planet 25  $c$ -years away. Both the earth and the distant planet are at rest relative to one another and their clocks have been previously synchronized, both reading zero when the spaceship passes earth. Just as the spaceship passes earth, the spaceship observer sets his clock to read zero. Precisely when the spaceship arrives at the distant planet, a light signal from the earth indicates that the earth has exploded.”

- a) Draw a set of three pictures in the rest frame of the spaceship, illustrating the three important events. Then answer the following questions, all from the point of view of observers at rest in the spaceship frame.
- b) How far apart are the earth and the distant planet?
- c) When the distant planet arrives at the ship, what does the ship clock read?
- d) When the distant planet arrives at the ship, what does the earth clock read?
- e) When the distant planet arrives at the ship, what does the distant planet clock read?
- f) When the earth explodes, what does the ship clock read?
- g) When the earth explodes, what does the earth clock read?
- h) When the earth explodes, what does the distant planet read?

4. Two identical twins Albert and Billy are separated at birth with Albert staying home on earth and Billy traveling at constant speed  $(12/13)c$  toward a distant planet. Both the earth and the distant planet are at rest relative to one another and their clocks have been previously synchronized, both reading zero when Billy departs earth. Just as Billy leaves earth, Billy sets his clock to also read zero.

Upon arriving at the distant planet, Billy quickly turns around and travels back home at the same speed. When Billy arrives home he is at his prime at 25.0 years old but finds that his identical twin has just passed away.

- a) Draw a set of two pictures in the rest frame of identical twin Albert for the two relevant events (Billy departing from Albert and Billy arriving at the distant planet). Which observer measures  $\Delta x' = 0$ ?
- b) How old was Albert at the time of his death?

- c) According to Albert, what is the distance to the distant planet from earth?
  - d) According to Billy, what is the distance that he traveled to reach the distant planet?
  - e) When Billy reaches the distant planet, what do all three clocks read?
5. Reconsider the two identical twins of the previous problem, this time from the rest frame of Billy.
- a) Draw a set of two pictures in the rest frame of identical twin Billy for the two relevant events (Albert departing Billy and the distant planet arriving at Billy).
  - b) Find the reading of all three clocks when Albert departs Billy.
  - c) Find the reading of all three clocks when the distant planet arrives at Billy.